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(54) **X-ray tube.**

(57) Off-focus radiation in an x-ray tube due to back-scattered radiation is substantially reduced by enclosing the anode target 28 in a metal enclosure which is maintained at the anode potential, enclosing the cathode in an attached, insulative envelope which is substantially separate from the anode enclosure, and by providing effective heat transfer from the anode enclosure to a cooling medium, especially at the area of impact of back-scattered electrons with the inner walls of the anode enclosure.

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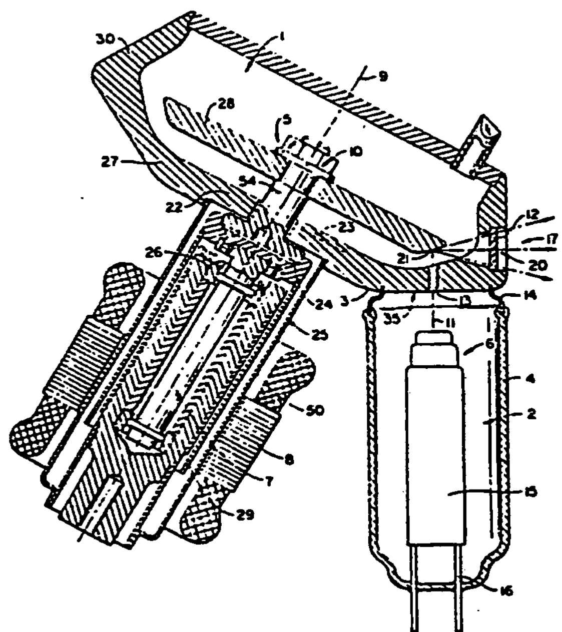
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FIG._1.

X-RAY TUBE

This invention relates to x-ray tubes and more particularly to an improved rotating anode type x-ray tube.

At present, the majority of x-ray tubes used in medical diagnostic work are of the rotating anode target type. Their main advantage is high power capability, which allows short exposures, thus minimizing image blurring by patient tissue motion. Although many improvements have been made on this tube type in the past, some of the inherent problems have not been overcome and limit the range of useful applications of the rotating anode x-ray tube. One problem is unwanted x-ray radiation emanating from areas on the rotating anode other than the focal spot area. These x-rays are generated by back-scattered electrons which are bouncing back from the point of impact on the target, usually after losing some of their primary energy. The number of back-scattered electrons reaches 50% of the number of primary electrons. This so-called off-focus radiation leads to decreased contrast in the x-ray image. It is also an unnecessary amount of radiation dose to the patient on the order of 10-25% of the useful radiation coming from the focal spot generated by the primary electron beam.

At the beginning of an exposure a large number of back-scattered electrons hit the glass envelope of the x-ray tube, until it is charged up to a level determined by the equilibrium between back-scattered

electrons, positive and negative ions, and currents leaking off through the glass envelope.

This equilibrium depends on the number of gas molecules present in the tube as well as on surface cleanliness of the glass bulb and glass bulk conductivity, all of which are functions of the temperatures of the various tube parts at any one time. Depending on this equilibrium, the equipotential pattern in the tube varies considerably in time as well as from tube to tube, leading to an unpredictable degree of high voltage instability in the tube, leading to an upredictable degree of high voltage instability in the tube. As a matter of fact, high voltage instability problems are a most common failure mode of x-ray tubes.

The back-scattered electrons, as well as ionized gas molecules also deposit energy on the glass surface, which can lead to glass cracking or melting and liberation of additional gas loads from the glass surface into the tube. This in turn causes high voltage arcing in the tube.

The back-scattered electrons are also responsible for unnecessary energy deposits on the rotating anode, which is about 30% to 40% of the total energy of the primary electrons. If the secondary electrons are not allowed to fall back onto the rotating anode, more of the useful primary radiation may be generated before the target heat limits are reached. This would increase the usage factor of an x-ray tube, which would have an influence on the economy of an x-ray department in areas where high x-ray tube loads are desired such as for special procedures and for tomographic procedures.

Another problem sometimes encountered in x-ray tubes is field emission. This is particularly unwanted when the current is turned off between exposures rather than the voltage. In this case, if the cathode exhibits points which emit field emission electrons, x-ray radiation is generated on the target by these electrons. Even though the radiation level of these x-rays is low, it's accumulated amount over long off-time periods can be large.

Metallic deposits are a further problem of conventional glass bulb x-ray tubes. These deposits come from two sources: from the tungsten filament of the cathode and from the focal spot area on the target. Metallic layers on the glass bulb change the electrical conductivity of the glass bulb and result in a change of the electrical environment in the tube.

Yet another problem in conventional x-ray tubes is that in certain applications, such as computed tomography, the x-ray load on the insulating oil can be so large that oil break up occurs. This is very undesirable since oil break up leads to high voltage arcing in the x-ray tube housing.

In one known construction, an attempt is made to reduce some of these problems. This construction is called a metal center section x-ray tube or a glass/metal x-ray tube.

The metal center section is located symmetrically between the anode and the cathode and is separated from each by a length of glass or ceramic and is kept essentially at ground potential. A portion of the back-scattered electrons with sufficient energy to reach this electrode will be collected by this electrode, thereby splitting a certain amount, approximately 15% off from the anode current. Also, the electron optics of such a tube structure remain more stable than that of an

all glass tube, since evaporating metallic molecules are essentially deposited on the metal section.

Some of the disadvantages of this construction are the difficulties of fabrication, and further the fact that the electrical wiring of the tube has to be made very carefully to avoid currents going through the protective x-ray tube housing and the tube mounting gear. A failure of a connection of the center section to ground or of the anode to the anode supply circuitry can easily lead to destroying the tube and cause electrical hazards to the patient or the technician.

In another known construction, as described in U.S. Patent 3,018,398 (Z. J. Atlee), the interior of the x-ray tube is equipped with a hood in order to prevent spurious x-rays from entering into the field of useful x-rays coming from the focal spot. This hood acts similarly to a near collimator, although it does not provide for a sight of substantially only the focal spot of the anode from any point from within a predetermined useful field of the x-rays generated at the focal spot. Also, if the hood member in this construction is at anode potential or at ground potential it will be heated up to high temperatures by the collected back-scattered electrons, with substantially only heat radiation as a means for dissipation of the collected energy.

The above and additional disadvantages sometimes found in rotating anode x-ray tubes are overcome by the present invention, wherein the anode is completely surrounded by a metal enclosure, which is maintained at anode potential. The anode enclosure can consist of other material than metal, as long as it is electrically conducting and also is a good conductor of heat. The cathode is in a separate, but attached enclosure forming a cathode compartment, mainly consisting of glass, ceramic or other electrically insulating material for electrical insulation between the cathode and anode potentials. Only a small hole connects the two compartments; just large enough to let the electron beam pass from the cathode to the focal spot area on the target. The anode enclosure as well as the cathode enclosure are both parts of the vacuum envelope of the tube and are both surrounded at the outside for cooling either by a liquid or gaseous substance, such as silicone oil or air. The surrounding substance can, if required, also act as an electrical insulating means for high voltage stand off between cathode and anode potential.

The main advantage of this construction is to substantially prevent the back-scattered electrons from returning to the anode and generating off-focus radiation thereupon. Since both the anode and the surrounding metal enclosure are at the same potential, the space between the two is electrically field free. This causes primary electrons emitted from the anode when back-scattered to move in straight lines toward the enclosure. In order to minimize x-ray emission from the inner walls of the anode enclosure and second back scatter events at the inner wall, which would allow a certain small portion of

electrons to reenter the anode and thereby generate a small amount of off-focus radiation, the enclosure is preferably made of or coated with a low atomic number element or compound. The coating must be at least as thick as the electron range of this material at the highest tube voltage. For most materials, a thickness of 100 micro-meters (um) or more is usually sufficient.

Since the number of back-scattered electrons and their average energy is high, a substantial amount of the primary electron energy is incident upon the anode enclosure. The spatial power density of this electron bombardment at the inner enclosure surface depends on the geometry of the anode compartment structure, and is highest in the area opposite the primary focal spot. It is, therefore, important to make the enclosure of a material of good heat conductivity, in order to facilitate transport of the incident electron energy to the outer surfaces of the enclosure, which are cooled by a cooling substance.

The wall of the enclosure at the area of impact is specially constructed to dissipate this heat. In one embodiment the wall is thickened compared to the wall thickness of the rest of the enclosure. In another embodiment fluid passages for a cooling medium are provided. In still another embodiment an annular space, open to the cooling medium, is provided at the juncture of the anode and cathode compartments.

Since the back-scattered electrons and their energy is absorbed by the enclosure, this energy is not contributing to the temperature of the rotating anode, as is the case with conventional rotating anode x-ray tubes. This is a distinct advantage, and increases the effective duty factor of the x-ray tube by 30 to 40%.

The new x-ray tube structure according to the invention eliminates almost completely any bombardment of the insulating dielectric cathode envelope by electrons. Only very few of the back-scattered electrons are on trajectories which pass through the hole connecting the cathode and anode compartments serving mainly for the passage of the primary electron beam. Back-scattered electrons finding their way through the hole will substantially fly parallel to the hole axis, reach a certain point more or less close to the cathode, depending on their energy, and then fall back towards the anode enclosure, and be absorbed by the enclosure with a high degree of probability.

By virtue of the compartment structure of the new tube, the likelihood that any field emission electrons generated at the cathode will pass through the connecting hole is very small. Therefore, x-ray emission from the target, which in conventional x-ray tubes usually is concentrated in a number of small spots caused by field emission, is virtually eliminated.

Another important advantage of the x-ray tube according to the invention is a reduction in metal deposits on dielectric, insulating surfaces, such as occur at the inner glass bulb surfaces of conventional x-ray tubes. Metal deposits evaporating from the anode will essentially be retained in the anode compartment, since evaporating molecules from the focal spot on the anode move in straight lines. Evaporation from the cathode structure, if any, will only cause deposits at that end of the cathode enclosure which is closest to the anode compartment. Since this end is mainly made up of electrically conducting materials, metallic deposits will not change the insulating properties of the tube. Even if some metallic deposit should occur on the dielectric

envelope, because of the geometric location of possible deposits it would not have any substantial effect on the symmetry of the electron optics nor on the insulation properties of the glass.

An additional advantage of the construction according to the invention is the very simple glass shape, which allows making use of glass with higher temperature performance, or using ceramic materials. This is particularly important for the vacuum outgassing bake period during tube manufacture. Higher bake temperatures usually allow the achievement of substantially improved vacuum levels.

In a preferred embodiment of the invention, the anode enclosure or a layer on the outer surface of the anode enclosure is made from substantially x-ray opaque material. This has the advantage of reducing the x-ray radiation load on the insulating oil, preventing the oil from cracking up into volatile gaseous fractions, the presence of which would reduce the insulating properties of the oil substantially. Additionally, x-ray opaqueness of the anode enclosure would reduce or eliminate the need of most of the x-ray shielding usually applied to the x-ray tube housing into which the x-ray tube is inserted for protection and safety, also containing the insulating liquid or gas.

It is therefore an object of the present invention to provide an x-ray tube having substantially reduced off-focus radiation.

It is another object of the invention to provide an x-ray tube emitting substantially reduced field emission x-rays.

It is still another object of the invention to provide an x-ray tube having reduced metal deposits on dielectric insulating surfaces.

The foregoing and other objectives, features and advantages of the invention will be more readily understood upon consideration of the following detailed description of certain preferred embodiments of the invention, taken in conjunction with the accompanying drawings.

Figure 1 is a vertical sectional view of an x-ray tube according to one embodiment of the invention;

Figure 2 is an enlarged, vertical sectional view of the target area of the tube depicted in Figure 1, with portions broken away;

Figure 3 corresponds to Figure 2 and depicts a first modification of the embodiment of Figure 1;

Figure 4 is a sectional view taken along the line 4-4 in Figure 3;

Figure 5 corresponds to Figure 2 and depicts a second modification of the embodiment of Figure 1;

Figure 6 is a vertical sectional view of a third modification of the embodiment of Figure 1;

Figure 7 is a vertical sectional view of an x-ray tube according to a second embodiment of the invention;

Figure 8 is a vertical sectional view of an x-ray tube according to a third embodiment of the invention;

Figure 9 corresponds to Figure 8 and depicts a modification of the third embodiment; and

Figure 10 is a sectional view taken generally along the lines 10-10 in Figure 9.

Referring in detail to the drawings, Figure 1 is an illustration of an x-ray generator tube embodying the invention. The x-ray tube is of the rotating anode type, which embodies a vacuum tight overall envelope 3 in which is supported an anode 5 and a cathode 6.

The anode 5 includes a disk shaped target 28 which is bolted onto a rotor nose piece 24 with a nut 10. The target 28 can also be heat shrunk onto the rotor nose piece 24. The composition of the target 28 may be of any

of the various types well known to those skilled in the art, such as a bulk consisting of molybdenum alloyed with small percentages of tungsten, or zirconium and titanium. Also, graphite based targets are commonly used in rotating anode x-ray tubes. The rotor nose piece is bolted or welded to a rotor assembly 7, comprising a target spindle 54 which is rotatably supported in a high performance double ball bearing system 26 and an outer skir 29. The rotor assembly is capable of rotating at high speeds when the surrounding inductive stator 8 is appropriately energized, acting on the outer skirt 29 by inductive, electro-magnetic forces. The cathode 6 is mounted at one end of a preferably cylindrical envelope 4, which is part of the vacuum tight envelope 3 of the x-ray tube. The cathode 6 can be either of the common filament type or of the dispenser type or any other suitable type. Application of suitable electrical voltages and currents generates an electron beam 11 of a certain size and cross sectional electron density distribution, which upon impinging on the rotating target 28 at the area of impact generates an x-ray focal spot 21, from which x-rays are emitted in all directions.

In accordance with this invention, the envelope 3 of the x-ray tube comprises three compartments: The anode compartment 1, the cathode compartment 2 and the rotor compartment 25. The anode compartment 1 which contains the target is formed by an envelope 30, which is part of the envelope 3 and is hermetically joined to the neck portion of the vacuum envelope 3 which contains the rotor assembly and comprises the rotor compartment 25 of the tube. The anode envelope 30 is made of an electrically conducting, substantially x-ray opaque, material which is also a good heat conductor.

The cathode compartment 2 contains a cathode gun 32 and is formed by the insulating envelope 4 and an outer surface 35 of the anode compartment envelope 30, to which the insulating envelope 4 is hermetically joined. The insulating envelope 4 can consist of glass or ceramic, for example. Attached to the rear end of the insulating envelope 4, which is remote from the joint with the anode compartment envelope, is a cathode support 15, including the electrical vacuum feed throughs 16 for energizing the cathode gun 32.

In operation, an electron emitter contained in the cathode gun structure 32 emits a cloud of electrons which is focused into an electron beam 11 and accelerated by a potential difference between the cathode gun 32 and the anode compartment envelope 30 towards a hole 13 in the envelope 30.

The hole 13 is large enough to admit the entire electron beam 11 which continues its path towards the target disk 28, being incident on the target disk 28 at the focal spot area 21. At the locus of incidence, electron radiation is converted into x-ray radiation which is directed in substantially a 2π solid angle. Only that portion of the x-ray beam directed towards a window 12 mounted within a frustoconical cut-out 20 in the anode envelope 30 is utilized for radiological purposes. The window 12 is hermetically sealed to the envelope 30 and consists of any suitable x-ray transmitting material, preferably beryllium, beryllia, or aluminum.

According to the invention, the main purpose of the anode enclosure 30 is to absorb electrons back-scattered from the focal spot area 21 on the target as they travel from the focal spot area 21 towards the surfaces of the anode enclosure 30 in substantially straight lines. Figure 2 depicts the area of impact of back-scattered electrons on the inner walls of the enclosure 30, which

area is indicated by the numeral 36. It is easily apparent that none of the back-scattered electrons is incident on the target 28 itself. Some of the x-rays generated at the impact area 36 of the anode enclosure, however, can reach certain loci 46 in the useful x-ray field 45, which is cut out from the total x-ray field by a beam limiting device 47, often called collimator. Also, a certain portion of back-scattered electrons are reback-scattered from the impact area 36.

Therefore, to more effectively fulfill the main objective of the invention, which is to minimize off-focus radiation and also to reduce the amount of reback-scattered electrons, the anode enclosure or portions thereof adjacent to the surface area 36 consists of a material comprised of elements with low atomic number. For instance, the back-scatter coefficient of beryllium is only 4%, compared to 50% of tungsten. A minimum thickness of 100um of a low atomic number material is sufficient to achieve the desired effect at the surface 36. Any material consisting mainly of elements with the atomic number of 29 or less has the desired quality of substantially reducing reback-scatter and off-focus x-ray radiation.

Since the back-scattered electrons carry with them large amounts of energy, which is deposited at the surfaces of the anode enclosure, large amounts of heat have to be dissipated by the enclosure 30. For the purpose of illustration reference is made again to Figure 2 where the area of electron impact 36 is also the area of heat impact on the inner walls of the enclosure 30. The heat is distributed over the enclosure walls, including the inner surface of window 12 of the enclosure 30, and is transferred to the outer surfaces 33, 34, and 35 of the envelope 30, if there exists a temperature gradient through the wall. Such a temperature gradient is

generated by cooling the outer surface of the enclosure with a liquid or a gaseous medium. The circular surface portion 35, however, is an interior surface of the cathode compartment and is, therefore, located within the high vacuum of the tube, so that heat from this surface portion 35 cannot be transferred to a cooling medium. Heat transfer by radiation is too small at the temperature present at surface 35.

Therefore, according to the objectives of this invention, the enclosure 30 is constructed in such a way that the wall thickness 37 at the juncture of the cathode and anode compartments is great enough to allow sufficient conductive heat flow from that portion of surface 36, which is opposite to the circular surface 35, to the outer surfaces 34 and 33 which are in contact with the cooling medium.

In Figure 3 and Figure 4, there is seen a modified embodiment of the invention. Figure 4 is a cross-sectional view of the embodiment of Figure 3 taken generally along the line 4-4 in Figure 3. In order to further improve the transfer of heat away from the impact area at the surface 36, two long holes are drilled into the enclosure 30, forming a v-shaped cooling conduit 38 which is contained in a hypothetical plane which is substantially parallel to the surface 35. The cooling medium is forced into the cooling conduit 38 by pumping means (not shown) via a hose 40 and a fitting 39 connected to one end of the conduit 38. The cooling conduit 38 as shown in Figures 3 and 4 is but one possible embodiment of cooling means for the anode enclosure near the focal spot, and other embodiments will be apparent to those skilled in the art.

Figure 5 shows the basic embodiment of the invention again modified for the purpose of intensified cooling at the surface 35, in which the cathode compartment 2 of Figure 1 is constricted to a small diameter at a member 42 which joins the cathode compartment insulating envelope 4 to the anode envelope 30 through a cylindrical neck 43. In this embodiment, most of the surface 35 is exposed for contact with the cooling medium for improved heat transfer through an annular gap 44 between the envelope 30 and the member 42.

Referring again to Figure 1, an important feature of the invention is that the metallic construction easily provides for a radiation barrier 22 between the hot target disk and the heat sensitive ball bearings. This heat barrier can also have other constructional shapes 23 (as shown in hidden line fashion at the right side of the target spindle 54 in Figure 1). In common x-ray tubes, the bearing system is a main limiting factor for high duty tube operation, as, for instance, encountered in computed tomography scanning. Eighty percent of the heat flowing into the bearing system is made up of radiation and only 20% is transferred by conduction along the target spindle 54.

The outer wall 50 of the tube in the vicinity of the rotor consists of a metal tube. This metal must be of low electrical conductivity in order not to restrict the energizing flow of electromagnetic power from the stator 8 to the rotor skirt 29. In other embodiments this tubular metal element can be replaced by a tubular glass element similar to the more common x-ray tubes, which are made essentially from a glass envelope. The tubular element could also be ceramic in still other embodiments.

In Figure 6 another embodiment of the invention is shown, with the two ball bearings 52 and 53 loacted at opposite sides of the target 28. The metallic wall construction of the invention lends itself easily to this embodiment, which greatly improves the stability of the target's rotation.

In Figure 7 an embodiment of the invention is shown which differs in two ways from the previously described embodiments. Firstly, the cathode compartment 2' is placed on the other side of the target disk 28 with regard to the rotor compartment 25'. This construction has advantages in terms of easier manufacture, and also allows magnets 55 to be placed around the cathode compartment 2' for improved electron beam focusing.

Secondly, the tube structure in the embodiment of Figure 7 is made of relatively thin metal sheets. The advantage of this construction is a much easier manufacture of the tube. The problem of possible overheating of the tube wall opposite to the focal spot 21' is avoided in a way similar to that of the embodiment shown in Figure 5.

Another embodiment of the invention is shown in Figure 8. In this construction, the x-ray beam emanates from the tube in a direction which is substantially parallel to the rotational axis 9'' of the target 28''. This is achieved by positioning the cathode 6'' at the outer circumference of the anode envelope 30'' and directing the electron beam 11'' against the target 28'' along a direction which is perpendicular to the axis 9''. The target 28'' is also inverted from its position in the embodiment of Figure 1.

This construction also lends itself to the application of more than one cathode, which is of value either for stereo type x-ray imaging or for providing more than one or two focal spots of differenct sizes in one x-ray tube, as shown in Figures 9 and 10.

While no high voltage source has been shown for supplying the anode to cathode electrostatic potential, such a source is to be understood as being connected in the conventional way, i.e. through high-voltage lead throughs and electrodes.

The terms and expressions which have been employed here are used as terms of description and not of limitations, and there is no intention, in the use of such terms and expressions of excluding equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

CLAIMS

1. An improved X-ray tube of the type having an anode, a cathode for generating a beam of electrons to impinge on the anode, whereby X-rays are produced, and a vacuum enclosure for the anode and cathode, wherein the improvement comprises an electrically conductive, walled enclosure for the anode, means for equalizing the electrical potential between the anode and the anode enclosure, a separate, electrically insulative enclosure for the cathode which enclosure is joined to the anode enclosure at a junction point, the anode and cathode enclosures having connecting openings therein to allow the passage of the beam of electrons generated by the cathode to impinge on the anode, and means integral with the anode enclosure for dissipating heat from the anode enclosure walls at the juncture of the anode and cathode enclosures.

2. An improved X-ray tube as recited in claim 1, wherein the anode enclosure is made of metal and the heat dissipating means include a portion of the anode enclosure which surrounds the opening to the cathode enclosure and which is thickened compared to the remaining walls of the anode enclosure.

3. An improved X-ray tube as recited in claim 1, wherein the heat dissipating means include cooling medium carrying passages within that portion of the anode enclosure wall which is located at the junction point with the cathode enclosure.

4. An improved X-ray tube as recited in claim 1, wherein the heat dissipating means include a hollow neck which joins the cathode enclosure to the anode enclosure at the junction point so as to separate the enclosures by an annular space for receiving a cooling medium.

5. An improved X-ray tube as recited in claim 1, further including rotor means for rotating the anode about an axis, an electrically conductive, walled enclosure for the rotor means, the rotor means enclosure being attached to the anode enclosure so that the two are at the same electrostatic potential, and a radiation barrier integral with the portion of the anode enclosure wall which separates the andoe and rotor enclosures.

6. An improved X-ray tube as recited in claim 5, further comprising a shaft for mounting the anode, a pair of bearing assemblies for rotatably supporting the anode shaft, and wherein one of the bearing assemblies is mounted in the rotor enclosure, on one side of the anode, and the other bearing assembly is mounted in the anode enclosure, on the side of the anode opposite from the rotor enclosure.

7. An improved X-ray tube as recited in claim 1, further including rotor means for rotating the anode about an axis, an enclosure for the rotor means, the rotor means enclosure being attached to the anode enclosure on one side of the anode, and the cathode enclosure being attached to the anode enclosure on the oppositie side of the anode.

8. An improved x-ray tube as recited in claim 1, further including rotor means for rotating the anode about an axis of rotation, and wherein the cathode projects the beam of electrons against the anode in a direction which is prependicular to the anode's axis of rotation, and the area of impact of the electron beam on the anode is oriented with respect to the cathode and the anode's axis of rotation such that the x-ray beam produced thereby is directed away from the rotor means in a direction generally parallel to the anode's axis of rotation.

9. An improved x-ray tube as recited in claim 8, further comprising a plurality of such cathodes for projecting a plurality of such x-ray beams.

10. An improved x-ray tube as recited in claim 1, wherein at least the interior portion of the anode enclosure which surrounds and is immediately adjacent to the opening to the cathode enclosure is comprised of a material of an atomic number not greater than 29 and has a thickness of at least 100um to substantially reduce reback-scattering of electrons and off-focus x-ray radiation.

11. An improved x-ray tube as recited in claim 10, wherein the material comprises beryllium.

12. An improved x-ray tube as recited in claim 1, wherein at least the outer protion of the anode enclosure is comprised of a substantially x-ray opaque material.

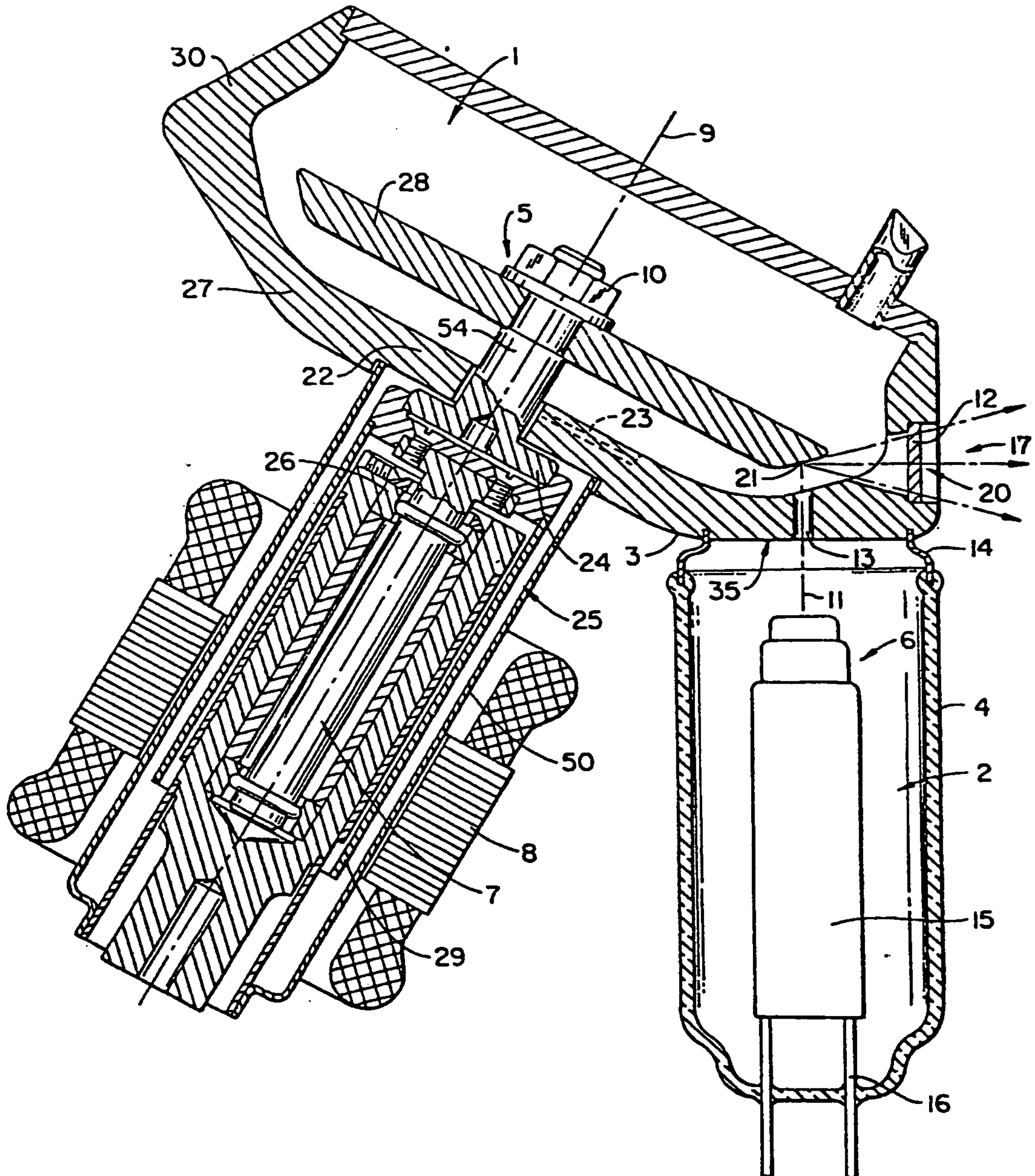
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FIG._1.

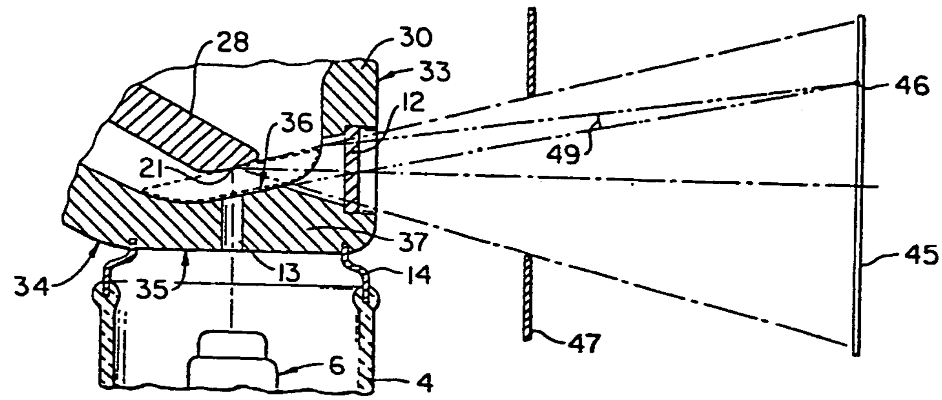

FIG._2.

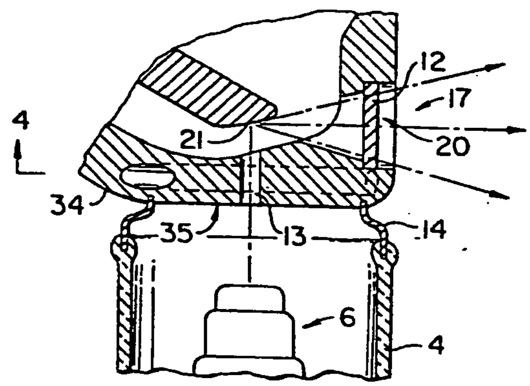

FIG._3.

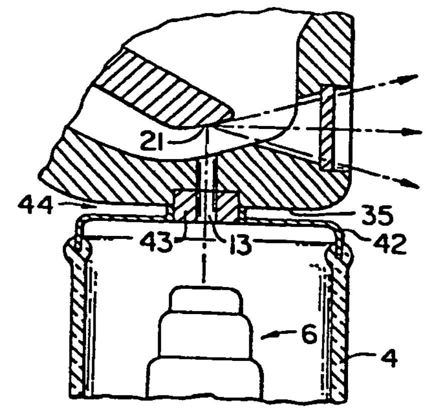

FIG._5.

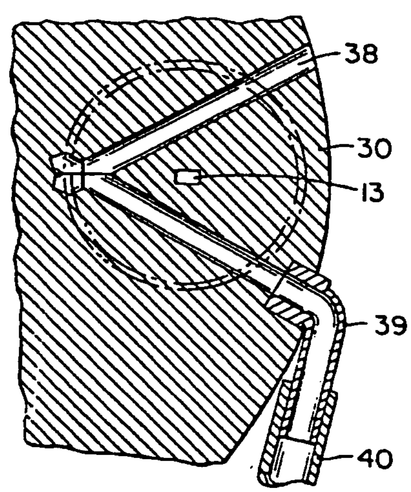

FIG._4.

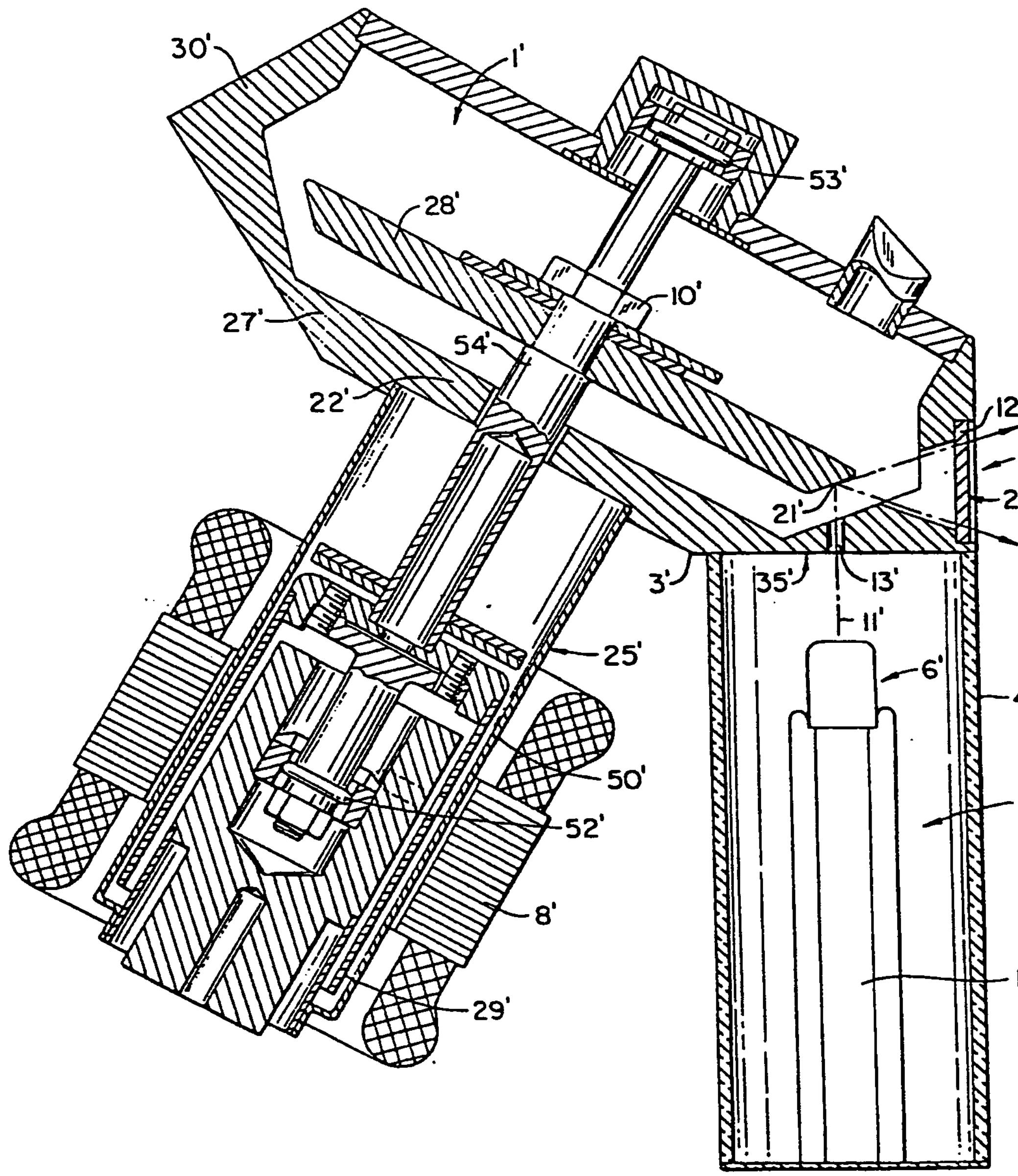

FIG.__6.

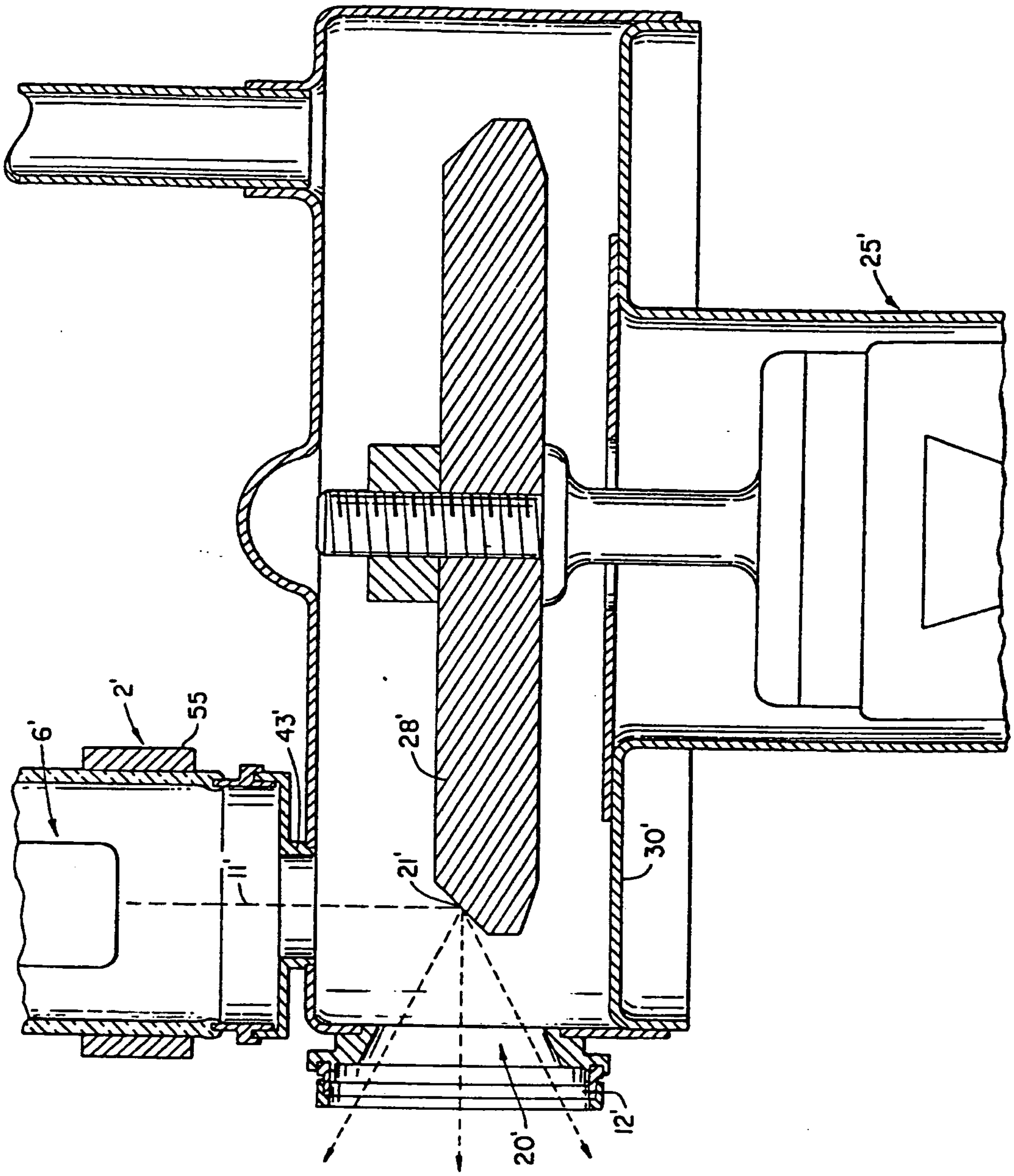

FIG._7.

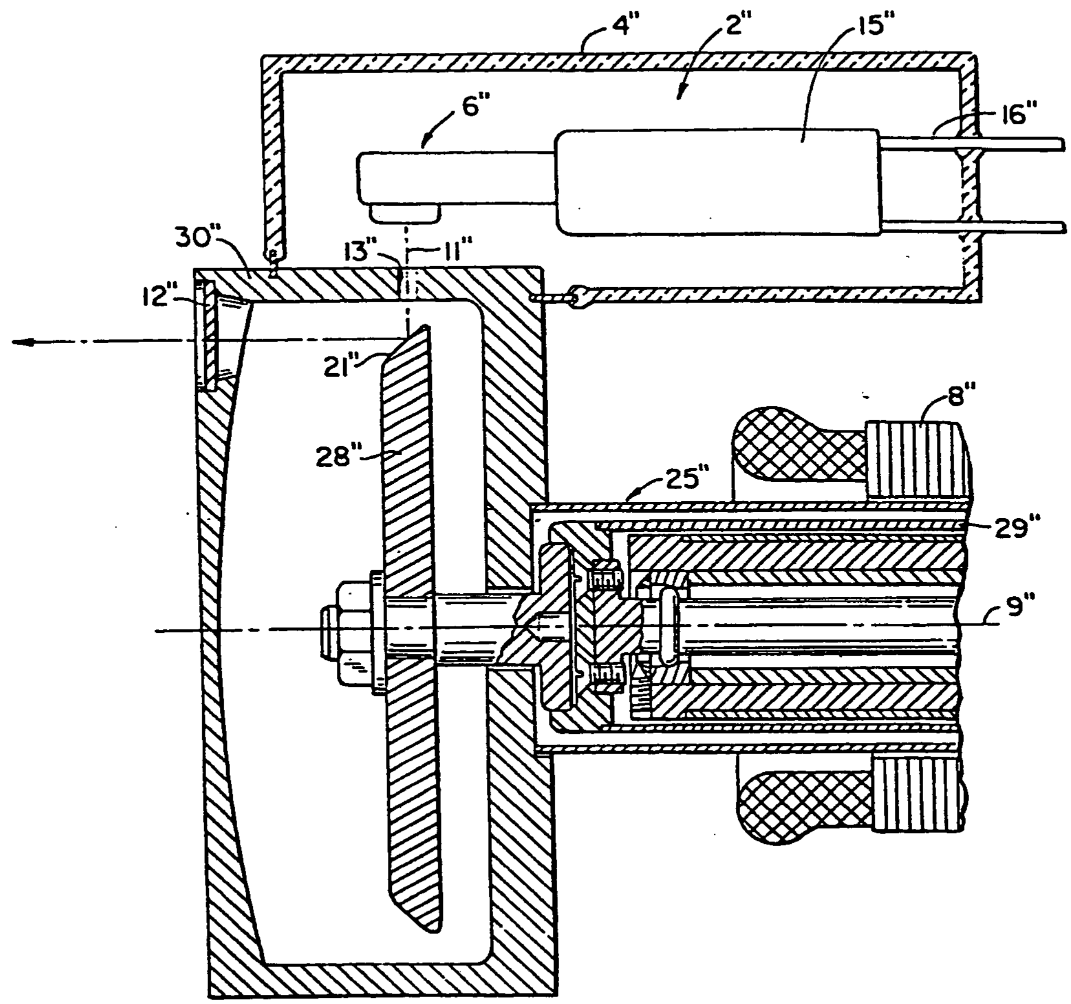

FIG._8.

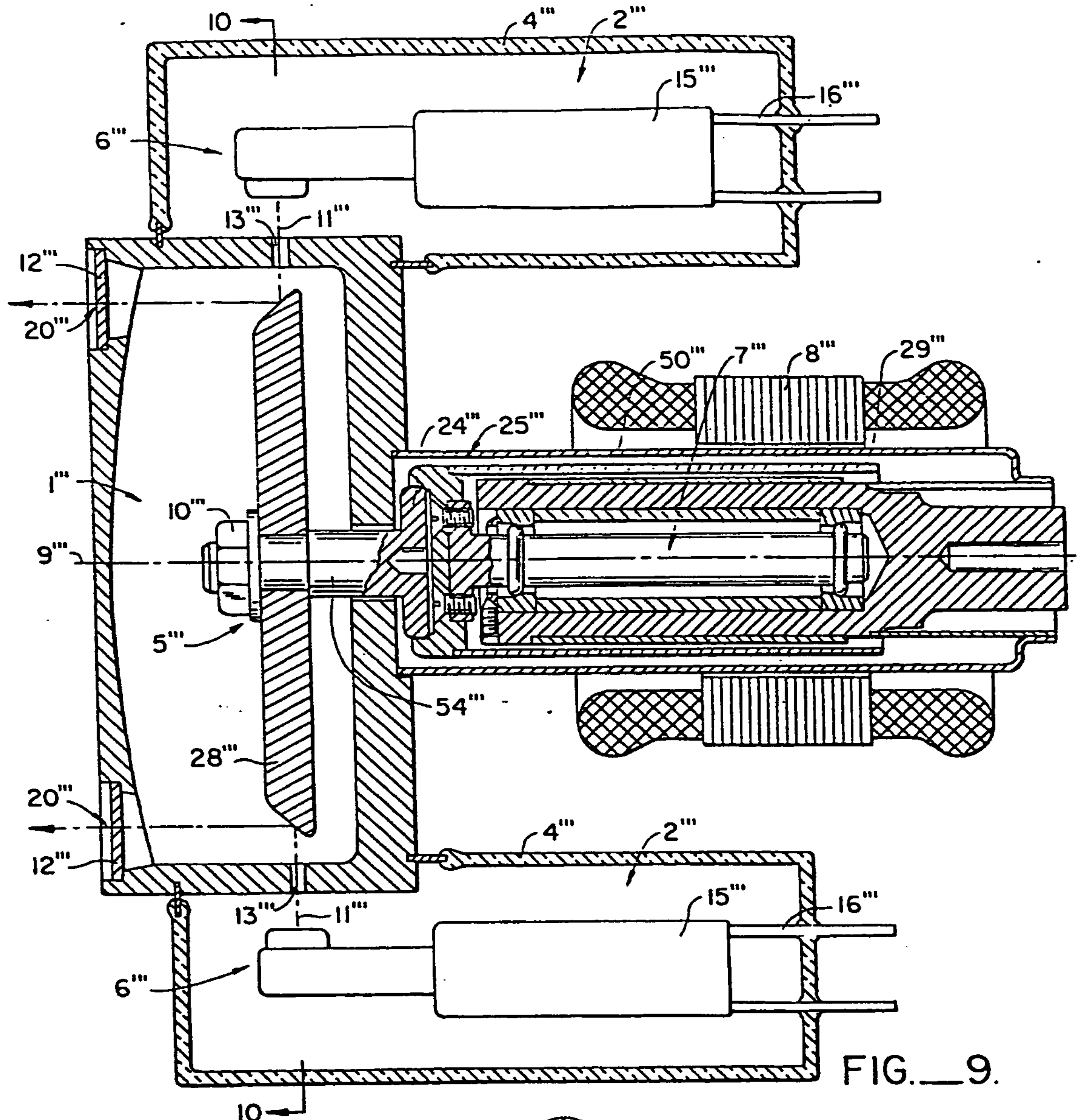

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FIG.__9.

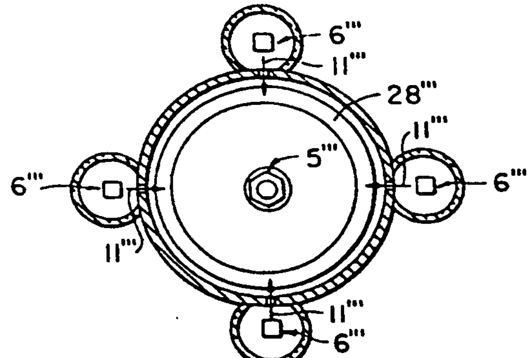

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FIG.__10.

European Patent Office

EUROPEAN SEARCH REPORT

Application number 0009946

EP 79302048.8

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
D	US - A - 3 018 398 (ATLEE) + Totality + --	1
X	AT - B - 297 865 (PHILIPS) + Claims 1 and 2; fig.; page 2, lines 6 to 29 + --	1-8, 10-12
	DE - A1 - 2 455 974 (PHILIPS) + Totality + & FR-A-2 293 054 & US-A-4 024 424 --	1,5-8
	US - A - 3 719 846 (PERENDS) + Column 1, lines 21 to 39, fig. + & FR-A-2 078 899 & GB-A-1 302 826 --	1,2,12
	GB - A - 701 893 (METROPOLITAN-VICKERS) + Page 2, lines 65 to 99 + --	1-4, 10-12
	GB - A - 1 214 083 (TOKYO SHIBAURA ELECTRIC CO. LTD) + Totality + ----	9

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

H 01 J 35/16
H 01 J 35/26

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

H 01 J 35/00
H 01 J 1/00
H 01 J 5/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	10-01-1980	KARLICEK

EPO Form 1503.1 06.78